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- Bugaj, Joseph Edward  
St. Charles, MO 63303 (US)
- Dorshow, Richard Bradley  
St. Louis, MO 63146 (US)
- Achilefu, Samuel  
Bridgeton, MO 63044 (US)

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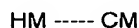
(71) Applicant: **Mallinckrodt Inc.**  
**St. Louis, Missouri 63134 (US)**

(74) Representative: **Jones, Alan John et al**  
**CARPMAELS & RANSFORD**  
**43 Bloomsbury Square**  
**London, WC1A 2RA (GB)**

(72) Inventors:  
• **Rajagopalan, Raghavan**  
**Maryland Heights, MO 63043 (US)**

**(54) Non-covalent bioconjugates useful for magnetic resonance imaging**

(57) A composition having non-covalent carrier-hapten bioconjugates of the formula:



wherein HM is a hapten molecule whose molecular weight is generally, but not always, less than 1000 Daltons and is capable of performing specific functions; CM is a carrier molecule, whose molecular weight is gener-

ally, but not always, more than 1000 Daltons and is capable of transporting the hapten to a specific site; and the dashed line is a non-covalent bond between the carrier molecule and the hapten molecule. Preferably, the bioconjugates are formed from a paramagnetic metal complex and a carrier molecule such as methylated serum albumin, polyarginine, lysine-phenylalanine copolymer, polyacrylamide-co-diallyldimethylammonium, arginine-serine copolymer, and styrene-maleic acid copolymer.

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**Description****BACKGROUND OF THE INVENTION****Field of the Invention**

**[0001]** This invention pertains to novel non-covalent carrier-hapten bioconjugates and their use in delivering diagnostic and therapeutic agents selectively to target tissues and organs. Particularly, this invention pertains to the selective delivery of paramagnetic non-covalent carrier-hapten bioconjugates to a specific site for the purpose of determining the structure and function of tissues or organs using magnetic resonance (MR) imaging procedures.

**Description of the Prior Art**

**[0002]** Non-covalent intermolecular forces (e.g., electrostatic, hydrogen bonding and Van der Waals interactions) play a vital role in many biological processes such as enzyme catalysis, drug-receptor interaction, antigen-antibody interaction, biotin-avidin interaction, DNA double helix formation, phagocytosis, pigmentation in plants and animals, and cellular transport. Many of the wide variety of colors observed in flowers and plants, for instance, are attributed to non-covalent association between the natural pigments and carbohydrates or proteins found in plant cells.

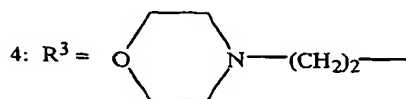
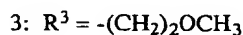
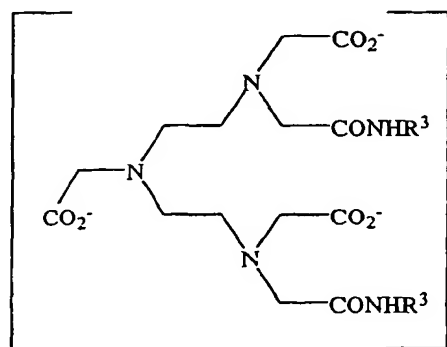
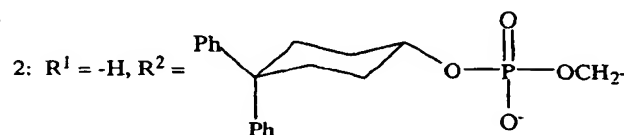
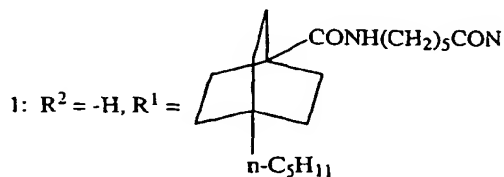
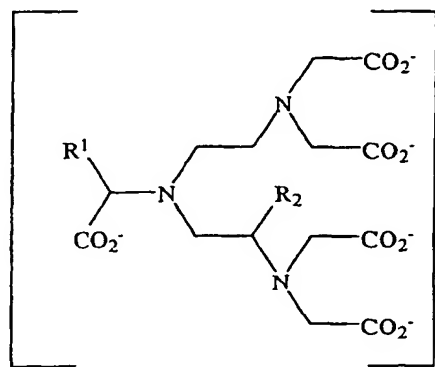
**[0003]** Non-covalent forces can alter the physicochemical and/or biological properties of haptens or carriers. For example, human serum albumin binds various molecules in a non-selective fashion and facilitates the transport of these molecules across the vasculature to the cells. Association of dyes or pigment molecules with proteins or carbohydrates usually changes the chemical or photo stability, changes the intensity and/or the wavelength of absorption/emission maxima, or both. Association of various paramagnetic gadolinium complexes to serum albumin has been shown to enhance the relaxivity of water protons by a factor of two (T.J. Brady and R.B. Lauffer, *Hepatobiliary NMR Contrast Agents*, Patent Application, **1986**, WO 8606605).

**[0004]** In non-covalent interactions, although the interaction energy per unit interaction is quite small (less than 40 kJ/interaction), the cumulative effect of multiple points of interaction along two surfaces can be substantial and can lead to strong binding between a hapten and a carrier. This approach has been successfully used to prepare anti-DNA antibodies. DNA is a highly charged anionic macromolecule that is normally non-immunogenic; but, when it is complexed with a highly charged cationic methylated bovine serum albumin (MBSA), DNA becomes immunogenic. A non-covalent DNA-MBSA bioconjugate is stable enough to elicit immune response toward DNA. It is clear from the examples above that noncovalently attached bioconjugates function biologically as a single unit. In addition to the above mentioned properties, the carrier molecule may also protect some haptens from chemical, photochemical, or radiolytic degradation.

**[0005]** The present invention is intended to exploit the concept of non-covalent interactions for the design of novel non-covalent bioconjugates for diagnosis using MR imaging procedures. Magnetic resonance contrast agents are widely used in diagnostic medicine. In conventional proton MRI, increased contrast of internal organs and tissues may be obtained by administering compositions containing a paramagnetic substance that increases the relaxation rate of water protons in its vicinity compared to the bulk water. In general, paramagnetic species such as ions of elements with atomic number 21 to 29, 42-44, and 58-70 have been found to be effective as MRI contrast agents. Examples of suitable ions include Cr(III), Mn(II and III), Fe(II and III), Co(II), Ni(II), Cu(II), Pr(III), Nd(III), Sm(III), Yb(III), Gd(III), Tb(III), Dy(III), Ho(III), and Er(III). Because of its high magnetic moment and short electronic correlation time, Gd(III) is the most preferred metal ion in the field of MRI contrast agents. It is always desirable and often necessary to increase the relaxivity of the metal complexes as much as possible. This increase in relaxivity has several benefits which include improvement in resolution, better contrast, reduced toxicity due to lower administered doses, or any combination of these factors. Furthermore, considerable increase in relaxation rate of surrounding water protons may be necessary to image organs, structures, and tissues that only receive a small percentage of the dose or that may be subject to high levels of background interference including motion artifacts. Recently, it was shown that covalent as well as non-covalent attachment of gadolinium complexes containing covalently attached albumin binding groups to serum albumin resulted in a four-fold increase in relaxivity as a result of a decrease in rotational correlation time brought about by strong binding of these complexes to albumin (B.M. Hofman et al., *Blood Pool Agent Strongly Improves 3D Magnetic Resonance Coronary Angiography Using an Inversion Pre-pulse*, Magnetic Resonance in Medicine, **1999**, 360-367; R. B. Lauffer et al., *Diagnostic Imaging Contrast Agents With Extended Blood Retention*, Patent Application, **1996**, WO 9623526; S.R. Woulfe, US Patent, **1999**, 5,888,476). However, the major disadvantage of these approaches is that they not only require conventional bioconjugate chemistry to attach the haptens to carriers, but, more importantly, they require the availability of strong albumin binding groups, which severely limits the range of compounds that may exhibit desirable albumin binding properties.

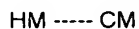
**[0006]** In conventional bioconjugate chemistry, conjugates are prepared by covalent attachment of various effector

molecules such as drugs, hormones, radiopharmaceutical agents, magnetic resonance imaging agents, chemotherapeutic agents, and the like to bioactive carriers. Such a process often involves cumbersome chemical manipulation of the two components, in addition to the complicated synthesis of appropriate activated haptens necessary for covalent attachment. Moreover, the bioactivity of the resulting conjugate is, in many cases, either greatly diminished or obviated altogether. Although the compounds **1** and **2** described by Lauffer



(R. B. Lauffer et al., *Diagnostic Imaging Contrast Agents With Extended Blood Retention*, Patent Application, 1996, WO 962352); and Woulfe (S.R. Woulfe, *Magnetic Resonance Blood Pool Agents*, US Patent, 1999, 5,888,476) bind to albumin in a noncovalent manner, their preparation requires first the covalent attachment of a special albumin binding group to the paramagnetic complex, which resulted in a complex synthetic procedure to prepare and attach this unit to the paramagnetic complex. Moreover, this process relies almost exclusively on the binding ability of that moiety to albumin, whereas in the present invention no such restriction is required. Indeed, the examples described later in the text indicate that the relaxivities of novel bioconjugates formed from **1** or **2** with a lysine-phenylalanine copolymer is higher than the corresponding albumin bioconjugates. Furthermore, compound **3**, which lacks a specific albumin binding group, shows a higher relaxivity when noncovalently associated with a lysine-phenylalanine copolymer as compared to the free complex. Finally, compound **4**, which has a tertiary amine side chain, binds so strongly to polyarginine that it results in formation of a solid precipitate. These observations provide further evidence that strong noncovalent binding can occur between a carrier and an effector molecule leading to a bioconjugate that functions as a single unit. Thus, there is a need for novel paramagnetic bioconjugates that are simple to prepare, exhibit high relaxivity, have easily modifiable binding strengths, and are stable enough to be useful as MRI agents.

[0007] WO-A-99 51284 discloses a composition comprising non-covalent carrier-hapten bioconjugates having the formula:



wherein HM is a hapten molecule selected from the group consisting of peptides, carbohydrates, photosensitizers, and fluorescent dyes; CM is a carrier molecule selected from the group consisting of proteins, glycoproteins, polypeptides, polysaccharides, inclusion compounds, polynucleotides, lipoproteins, and surfactants; and the dashed line is a non-

covalent bond between the carrier molecule and the hapten molecule.

# SUMMARY OF THE INVENTION

**[0008]** It is, therefore, an object of the present invention to provide novel compositions for increasing the relaxivity of paramagnetic complexes via non-covalent association of paramagnetic agents to selected carrier molecules.

**[0009]** It is a further object of the present invention to provide a method for performing a MR diagnostic procedure on a patient.

**[0010]** These objectives are achieved using new and structurally diverse non-covalent carrier-hapten bioconjugates having the formula:



wherein HM is a hapten molecule whose molecular weight is generally, but not always, less than 1000 Daltons and is capable of performing specific functions; CM is a carrier molecule, whose molecular weight is generally, but not always, more than 1000 Daltons and is capable of transporting the hapten to a specific site; and the dashed line represents one or more non-covalent bonds between the carrier molecule and the hapten molecule.

**[0011]** Preferably, the bioconjugates are formed from paramagnetic agents and carrier molecules selected from the group consisting of serum albumin, methylated serum albumin, polypeptides with molecular weight ranges from 2000 to 200000 Daltons, polysaccharides with molecular weight ranges from 2000 to 200000 Daltons, polynucleotides with molecular weight ranges from 2000 to 100000 Daltons, cyclodextrins, calixarenes, surfactants, and other natural or synthetic polymeric substances with molecular weights from 2000 to 200000 Daltons.

**[0012]** Most preferably, the bioconjugates are formed from paramagnetic agents selected from the group consisting of paramagnetic metal complexes such as lanthanide, manganese, and iron complexes; super paramagnetic iron oxide particles; or organic free radicals such as nitroxyl radicals whose carbon containing portions contain 1 to 20 carbon atoms; and cationic carrier molecules selected from the group consisting of methylated serum albumin, polyarginine, polylysine, polyornithine, and mixed polyamino acids such as 1:1 poly(lysine/phenylalanine), 3:1 poly (arginine/serine) and the like.

**[0013]** The multiple points of interaction between the hapten and the carrier essentially immobilize the paramagnetic hapten molecule thereby decreasing the rotational correlation time of the paramagnetic agent. Hence, the bioconjugates of this invention are useful as diagnostic agents in medical procedures because they have substantially increased relaxivity compared to free paramagnetic agents and are stable.

**[0014]** Other objects, advantages, and novel features of the present invention will become apparent in the following detailed description of the invention.

# DETAILED DESCRIPTION OF THE INVENTION

**[0015]** The present invention provides new and structurally diverse non-covalent carrier-hapten bioconjugates having the formula:



wherein HM is a hapten molecule whose molecular weight is generally, but not always, less than 1000 Daltons and is capable of performing specific functions; CM is a carrier molecule, whose molecular weight is generally, but not always, more than 1000 Daltons and is capable of transporting the hapten to a specific site; and the dashed line represents one or more non-covalent bonds between the carrier molecule and the hapten molecule.

**[0016]** The hapten is either a small molecule or a macromolecule and is selected from the group consisting of peptides, carbohydrates, fluorescent dyes, and paramagnetic agents. The hapten can also be a molecule such as a hormone, antibody, anti-neoplastic agent, enzyme, coenzyme, peptidomimetic, glycomimetic, cell adhesion molecule, radionuclide metal complex, magnetic resonance imaging agent, X-ray opacification agent, or echogenic agent. Perfluorocarbons with a carbon containing portion with 1 to 20 carbon atoms can also be used as haptens.

**[0017]** Preferably, the hapten is a charged or neutral paramagnetic agent such as a paramagnetic metal complex containing either anionic residues such as carboxylate, sulfonate, or phosphonate groups capable of forming non-covalent ion-pair association with cationic carriers; cationic residues such as ammonium or phosphonium groups capable of forming non-covalent ion-pair associations with anionic carriers; lipophilic groups, e.g., lipophilic polyamino acids, capable of binding with lipophilic portions of the carrier molecule via dispersion forces; or neutral electron pair

donors (Lewis bases) such as amino groups capable of forming hydrogen bonding association with carriers containing hydrogen donor groups such as carboxylic acids or alcohols. Most preferably, the hapten is a negatively charged paramagnetic gadolinium, manganese, or iron complex containing anionic lipophilic residues.

**[0018]** The carrier is selected from the group consisting of proteins such as albumins and globulins, glycoproteins, polypeptides, polysaccharides, polynucleotides, lipoproteins, surfactants, polycarboxylic acids, polyamines, polyamides, polyalcohols, polyethers and other natural or synthetic polymeric substances.

**[0019]** Preferably, the carrier is a macromolecule selected from the group consisting of proteins such as albumin or methylated albumin, glycoproteins such as antibodies or selectins, polysaccharides such as inulin or lectins, polynucleotides such as DNA or RNA or polymers such as polyadenylate, polyuridylate, polythymidylate, polyguanylate and polycytidylate, inclusion agents such as cyclodextrins or calixarenes, polyamino acids with one or many different amino acid types, synthetic polymers containing charged groups and aromatic rings, and surfactants such as Tween. Most preferably the carrier is a polymeric amino acid containing one or more of the amino acids arginine, lysine, histidine, serine or phenylalanine, or is a synthetic polymer containing styrene and quaternary ammonium groups.

**[0020]** In a preferred embodiment, a bioconjugate consists of a paramagnetic metal complex hapten and a polycationic carrier selected from the group consisting of polyarginine and a 1:1 polymer of lysine and phenylalanine wherein the hapten and the carrier are held together by non-covalent forces.

**[0021]** In another preferred embodiment, a bioconjugate consists of a paramagnetic metal complex hapten and a polyanionic carrier selected from the group consisting of polyacrylate, polyaspartate, polycarboxylate and polyglutamate wherein the hapten and the carrier are held together by non-covalent forces.

**[0022]** In another preferred embodiment, a bioconjugate consists of a paramagnetic metal complex hapten and a neutral carrier selected from the group consisting of polysaccharide, polyserine, and polyalcohol acids wherein the hapten and the carrier are held together by non-covalent forces. Polyacrylamide-co-allyldimethylamine copolymer is one example of a neutral carrier which can be used.

**[0023]** The paramagnetic agents as well as the carriers of the present invention may vary widely depending on the contemplated application. For blood persistent agents high molecular weight (>50,000 Daltons) polymers are preferable. For renal function measurements, a polysaccharide or anionic polypeptide is desirable.

**[0024]** The paramagnetic complexes 1-4 employed in this invention have been described previously in the following references which are incorporated herein by reference (R. B. Lauffer et al., *Diagnostic Imaging Contrast Agents With Extended Blood Retention*, Patent Application, 1996, WO 9623526; and S.R. Woulfe, 1999, *Magnetic Resonance Blood Pool Agents*, US Patent 5,888,476; C.F.G.C. Gerald et al., *Preparation, Physico-Chemical Characterization, and Relaxometry Studies of Various Gadolinium-DTPA-Bis(Amide) Derivatives as Potential Magnetic Resonance Contrast Agents*, *Magnetic Resonance Imaging*, 1995, 13(3), 401-420). The non-covalent carrier-hapten bioconjugates of this present invention can be advantageously prepared by simply mixing the two components in an optimal stoichiometric proportion and administering an effective amount of this mixture contained in a pharmaceutically acceptable formulation into an individual either systemically or locally to the organ or tissue to be studied. Alternatively, the bioconjugates can be isolated and stored by methods well known in the art. The novel bioconjugates of the present invention have broad clinical utility, which includes, but is not limited to, diagnostic imaging of tumors, inflammation (both sterile and bacterial), impaired vasculature, and myocardial viability.

**[0025]** The novel bioconjugates of this invention can be formulated into diagnostic compositions for enteral, parenteral, or oral administration. These compositions contain an effective amount of bioconjugate along with conventional pharmaceutical carriers and excipients appropriate for the type of administration contemplated. These compositions may also include stabilizing agents such as ascorbic or gentisic acid. For example, parenteral compositions advantageously contain a sterile aqueous solution or suspension of bioconjugates whose concentration ranges from about 1  $\mu$ M to about 1 M. Preferred parenteral formulations have a concentration of bioconjugates of 100  $\mu$ M to 1 M. Such solutions also may contain pharmaceutically acceptable buffers and, optionally, electrolytes such as sodium chloride. Formulations for enteral administration may vary widely as is well-known in the art. In general, such formulations are liquids which include an effective amount of bioconjugates in aqueous solution or suspension. Such enteral composition may optionally include buffers, surfactants, thixotropic agents, and the like. Compositions for oral administration may also contain flavoring agents and other ingredients for enhancing their organoleptic qualities.

**[0026]** The diagnostic compositions are administered in doses effective to achieve the desired diagnostic objective. Such doses may vary widely depending upon the particular bioconjugates employed, the organs or tissues to be examined, the equipment employed in the clinical procedure, and the like.

**[0027]** The present invention also provides a method of performing a diagnostic procedure on a patient for the purpose of determining the structure and function of tissues or organs. The method comprises administering the non-covalent carrier-hapten bioconjugates of the present invention to a patient, allowing the bioconjugates to become localized in or around a tissue or organ, and performing a diagnostic procedure such as a magnetic imaging tomographic imaging procedure.

**[0028]** The present invention also provides a method for altering the blood persistence of a hapten by forming the

non-covalent carrier-hapten bioconjugates of the present invention. Some bioconjugates are more stable *in vivo* than the hapten alone and are cleared from the patient's blood at a slower rate than the hapten alone. The slow blood clearance rate provides more time for doing a diagnostic and therapeutic medical procedure because the hapten remains in the blood system of the patient for an extended period. Other bioconjugates are less stable *in vivo* than the hapten alone and are cleared from the patient's blood at a faster rate than the hapten alone. The faster blood clearance rate requires less time for doing a diagnostic and therapeutic medical procedure because the hapten remains in the blood system of the patient for a shorter period. This means that the patient can spend less time having the procedure and recuperating.

**[0029]** The following examples illustrate the specific embodiment of the invention described in this document. As will be apparent to skilled artisans, various changes and modifications are possible and are contemplated within the scope of the invention described.

## EXPERIMENTAL PROCEDURES

**[0030]** The following is a general procedure for the preparation and relaxivity measurements of paramagnetic bioconjugates. A mixture of the haptens **1**, **2** or **3** and the carriers polyarginine (average MW = 11,800 Daltons), 1:1 lysine-phenylalanine copolymer (average MW = 43,000), polyacrylamide-co-diallyldimethyl ammonium copolymer, serum albumin, 3:1 arginine-serine copolymer (average MW = 27,300), or styrene-maleic acid copolymer (average MW = 120,000) in water or physiological saline were kept at ambient temperature for 5 minutes and their relaxivity was measured at 40 °C using a Bruker 20 MHz spectrometer. The final concentrations of each of the species ranged from 0.1 to 1.0 mM. The relaxivities (i.e.,  $T_1$  values) of compounds **1**, **2**, **3** and **4** in pure water are 7.6, 6.2, 5.0 and 5.1, respectively.  $T_1$  values of bioconjugates are given in the individual experimental sections.

### Example 1

#### Bioconjugate of **1** and polyarginine

**[0031]** Concentrations of **1** and polyarginine are 0.25 mM and 0.5 mM, respectively. Relaxivity of this bioconjugate is 15.6.

### Example 2

#### Bioconjugate of **1** and lysine-phenylalanine copolymer

**[0032]** Concentrations of **1** and lysine-phenylalanine copolymer are 0.25 mM and 0.12 mM, respectively. Relaxivity of this bioconjugate is 32.4.

### Example 3

#### Bioconjugate of **1** and polyacrylamide-co-diallyldimethylammonium copolymer

**[0033]** Concentrations of **1** and polyacrylamide are 0.25 mM and 0.12 mM, respectively. Relaxivity of this bioconjugate is 9.6.

### Example 4

#### Bioconjugate of **1** and arginine-serine copolymer

**[0034]** Concentrations of **1** and arginine-serine copolymer are 0.25 mM and 0.18 mM, respectively. Relaxivity of this bioconjugate is 16.0.

### Example 5

#### Bioconjugate of **1** and styrene-maleic acid copolymer

**[0035]** Concentrations of **1** and styrene-maleic acid copolymer are 0.25 mM and 0.0003 mM, respectively. Relaxivity of this bioconjugate is 18.0.

Example 6

Bioconjugate of 1 and serum albumin

5 [0036] Concentrations of 1 and serum albumin are 0.25 mM and 0.67 mM, respectively. Relaxivity of this bioconjugate is 29.6.

Example 7

10 Bioconjugate of 2 and polyarginine

[0037] Concentrations of 2 and polyarginine are 0.5 mM and 0.5 mM, respectively. Relaxivity of this bioconjugate is 7.8.

15 Example 8

Bioconjugate of 1 and lysine-phenylalanine copolymer

20 [0038] Concentrations of 1 and lysine-phenylalanine copolymer are 0.5 mM and 0.12 mM, respectively. Relaxivity of this bioconjugate is 36.2.

Example 9

Bioconjugate of 1 and arginine-serine copolymer

25 [0039] Concentrations of 1 and arginine-serine copolymer are 0.5 mM and 0.18 mM, respectively. Relaxivity of this bioconjugate is 8.4.

Example 10

30 Bioconjugate of 1 and styrene-maleic acid copolymer

[0040] Concentrations of 1 and styrene-maleic acid copolymer are 0.5 mM and 0.0003 mM, respectively. Relaxivity of this bioconjugate is 11.4.

35 Example 11

Bioconjugate of 1 and serum albumin

40 [0041] Concentrations of 1 and serum albumin are 0.5 mM and 0.67 mM, respectively. Relaxivity of this bioconjugate is 30.0.

Example 12

45 Bioconjugate of 2 and serum albumin

[0042] Concentrations of 2 and serum albumin are 0.25 mM and 0.67 mM, respectively. Relaxivity of this bioconjugate is 29.6.

50 Example 13

Bioconjugate of 3 and styrene-maleic acid copolymer

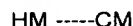
55 [0043] Concentrations of 3 and styrene-maleic acid copolymer are 1.0 mM and 0.12 mM, respectively. Relaxivity of this bioconjugate is 5.5.

[0044] Although the invention has been described with respect to specific modifications, the details thereof are not to be construed as limitations, for it will be apparent that various equivalents, changes, and modifications may be resorted to without departing from the spirit and scope thereof, and it is understood that such equivalent embodiments

are to be included therein.

## Claims

1. A diagnostic composition comprising a non-covalent carrier-hapten bioconjugate having the formula:



wherein HM is a hapten molecule selected from the group consisting of paramagnetic metal complexes, super paramagnetic iron oxide particles, perfluorocarbons with a carbon containing portion with 1 to 20 carbon atoms, and organic free radicals with a carbon containing portion with 1 to 20 carbon atoms; CM is a neutral or charged polymeric carrier molecule selected from the group consisting of polycarboxylic acids, polyalcohols, polypeptides, polyamino acids, polyamines, polyammonium compounds, polysaccharides, polyamides, polyethers, polynucleotides, inclusion compounds, and surfactants; and the dashed line represents one or more non-covalent bonds between the carrier molecule and the hapten molecule.

2. The composition of claim 1 wherein HM is a paramagnetic metal complex.
3. The composition of claim 1 or claim 2 wherein said hapten molecule comprises a carboxylate, a sulfonate, a phosphonate, ammonium groups, phosphonium groups, lipophilic groups or a neutral electron pair donor.
4. The composition of any one of claims 1 to 3 wherein CM has a molecular weight in the range 2000 to 200000 Daltons.
5. The composition of any one of claims 1 to 4 wherein CM is selected from the group consisting of polyalcohols, polypeptides, polyaminoacids, polyamines, polyammonium compounds, and polyamides.
6. The composition of claim 5 wherein said polypeptides are selected from the group consisting of albumins, globulins, glycoproteins and lipoproteins.
7. The composition of claim 1 wherein HM is a paramagnetic metal complex comprising an element with an atomic number selected from the group consisting of atomic numbers 21-29, 42-44 and 58-70; and CM is a cationic polymer with a molecular weight range of 2000 to 200000 Daltons and is selected from the group consisting of polylysine, polyarginine, polyornithine, arginine-serine copolymer, lysine-phenylalanine copolymer, diallyldimethylammonium copolymer, and methylated bovine serum albumin.
8. The composition of claim 7 wherein CM is polylysine, polyarginine, arginine-serine copolymer, lysine-phenylalanine copolymer or polyacrylamide-co-diallyldimethyl ammonium copolymer.
9. The composition of claim 1 wherein HM is a paramagnetic metal complex comprising an element with an atomic number selected from the group consisting of atomic numbers 21-29, 42-44 and 58-70; and CM is a neutral polymer having a molecular weight range of 2000 to 200000 Daltons and is selected from the group consisting of polyalcohols, polysaccharides, polyethers, polypeptides and polyamines.
10. The composition of claim 9 wherein CM is polyhistidine, polyacrylamide-co-allyldimethylamine copolymer, polyserine or inulin.
11. The composition of claim 1 wherein HM is a paramagnetic metal complex comprising an element with an atomic number selected from the group of atomic numbers 21-29, 42-44 and 58-70; and CM is an anionic polymer having a molecular weight range of 2000 to 200000 Daltons and is selected from the group consisting of polyacrylate, polyaspartate, polyglutamate, polycarboxylates and polynucleotides.
12. The composition of claim 11 wherein CM is styrene-maleic acid copolymer, polyacrylate, polyaspartate, polyglutamate, polycarboxylate, polyadenylate, polyuridylate, polythymidylate, polyguanylate, or polycytidylate.
13. The composition of any one of claims 7 to 12 wherein HM comprises a paramagnetic complex comprising a gad-



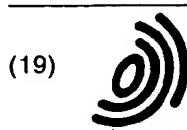
linium ion, a manganese ion or an iron ion.

14. The composition of claim 1 wherein HM comprises a paramagnetic complex comprising a gadolinium ion and CM is polyarginine.

15. A composition according to any one of claims 1 to 14, or the bioconjugate thereof, for performing a magnetic resonance diagnostic procedure.

16. A method of performing a magnetic resonance diagnostic procedure on a patient comprising administering to a patient an effective amount of a diagnostic composition according to any one of claims 1 to 14 or the bioconjugate thereof.

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Bridgeton, MO 63044 (US)

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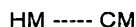
(71) Applicant: Mallinckrodt Inc.  
St. Louis, Missouri 63134 (US)

(74) Representative: Carpmaels & Ransford  
43 Bloomsbury Square  
London WC1A 2RA (GB)

(72) Inventors:  
• Rajagopalan, Raghavan  
Maryland Heights, MO 63043 (US)

(54) **Non-covalent bioconjugates useful for magnetic resonance imaging**

(57) A composition having non-covalent carrier-hapten bioconjugates of the formula:



wherein HM is a hapten molecule whose molecular weight is generally, but not always, less than 1000 Daltons and is capable of performing specific functions; CM is a carrier molecule, whose molecular weight is generally, but not always, more than 1000 Daltons and is ca-

pable of transporting the hapten to a specific site; and the dashed line is a non-covalent bond between the carrier molecule and the hapten molecule. Preferably, the bioconjugates are formed from a paramagnetic metal complex and a carrier molecule such as methylated serum albumin, polyarginine, lysine-phenylalanine copolymer, polyacrylamide-co-diallyldimethylammonium, arginine-serine copolymer, and styrene-maleic acid copolymer.

EP 1 106 186 A3



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# PARTIAL EUROPEAN SEARCH REPORT

Application Number

which under Rule 45 of the European Patent Convention shall be considered, for the purposes of subsequent proceedings, as the European search report

EP 00 31 0690

DOCUMENTS CONSIDERED TO BE RELEVANT			
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
X, D	WO 99 51284 A (ACHILEFU SAMUEL I ; DORSHOW RICHARD B (US); BUGAJ JOSEPH E (US); MA) 14 October 1999 (1999-10-14)	1-13, 15, 16	A61K49/00 A61K49/12
Y	* page 6, line 10-12 * * claims 1, 5, 7 *	1-16	
X	TOTH, EVA ET AL: "Direct assessment of water exchange on a Gd(III) chelate bound to a protein" JBIC, JOURNAL OF BIOLOGICAL INORGANIC CHEMISTRY (1998), 3(6), 606-613, XP001100694 * abstract *	1-7, 9, 13, 15, 16	
Y	US 4 880 008 A (LAUFFER RANDALL B) 14 November 1989 (1989-11-14) * column 3, line 39-52 *	1-16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)
			A61K
INCOMPLETE SEARCH			
<p>The Search Division considers that the present application, or one or more of its claims, does/do not comply with the EPC to such an extent that a meaningful search into the state of the art cannot be carried out, or can only be carried out partially, for these claims.</p> <p>Claims searched completely :</p> <p>Claims searched incompletely :</p> <p>Claims not searched :</p> <p>Reason for the limitation of the search:</p> <p>see sheet C</p>			
Place of search		Date of completion of the search	Examiner
THE HAGUE		18 June 2003	Gonzalez Ramon, N
CATEGORY OF CITED DOCUMENTS			
<p>X : particularly relevant if taken alone</p> <p>Y : particularly relevant if combined with another document of the same category</p> <p>A : technological background</p> <p>O : non-written disclosure</p> <p>P : intermediate document</p>		<p>T : theory or principle underlying the invention</p> <p>E : earlier patent document, but published on, or after the filing date</p> <p>D : document cited in the application</p> <p>L : document cited for other reasons</p> <p>&amp; : member of the same patent family, corresponding document</p>	

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Although claim 16 is directed to a diagnostic method practised on the human/animal body (Article 52(4) EPC), the search has been carried out and based on the alleged effects of the compound/composition.

Claim(s) searched completely:  
7,8,10-12,14

Claim(s) searched incompletely:  
1-6,9,13,15,16

Reason for the limitation of the search:

Present claims 1-6,9,13,15,16 relate to an extremely large number of possible compounds defined as: "non-covalent carrier-hapten bioconjugate", "hapten molecule" (claim 1); "paramagnetic metal complexes" (claims 1, 2); "super paramagnetic iron oxide particles", "perfluorocarbons with a carbon containing portion with 1-20 carbon atoms", "organic free radicals with a carbon containing portion with 1-20 carbon atoms" (claim 1); "neutral or charged polymeric carrier molecule", "polycarboxylic acids" (claim 1); "polyalcohols", "polypeptides", "polyamino acids", "polyamines", "polyammonium compounds", "polyamides" (claims 1, 5, 9); "albumins", "globulins", "glycoproteins", "lipoproteins" (claim 6); "polysaccharides", "polyethers" (claims 1, 9); "polynucleotides" (claims 1, 11); "inclusion compounds", "surfactants" (claim 1); "carboxylate", "sulfonate", "phosphonate", "ammonium groups", "phosphonium groups", "lipophylic groups", "neutral electron pair donor" (claim 3).

Support within the meaning of Article 84 EPC and disclosure within the meaning of Article 83 EPC is to be found, however, for only a very small proportion of the compounds claimed.

In the present case, the claims so lack support, and the application so lacks disclosure, that a meaningful search over the whole of the claimed scope is impossible. Consequently, the search for the first invention has been carried out for those parts of the claims which appear to be supported and disclosed, namely those parts relating to the compounds prepared in the examples and those specifically mentioned by chemical name in claims 7, 8, 10-12, 14.



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DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
X	SAHA T K ET AL: "PREPARATION AND EVALUATION OF GLUTARALDEHYDE CROSS-LINKED CHITOSAN MICROSPHERES AS A GADOLINIUM RESERVOIR FOR NEUTRON-CAPTURE THERAPY" CHEMICAL AND PHARMACEUTICAL BULLETIN, PHARMACEUTICAL SOCIETY OF JAPAN. TOKYO, JP, vol. 46, no. 3, 1 March 1998 (1998-03-01), pages 537-539, XP000748999 ISSN: 0009-2363 * abstract *	1-6, 9, 13, 15, 16	
A	WO 89 11874 A (BRAYBROOK JULIAN HUGH ; HALL LAURENCE DAVID (GB)) 14 December 1989 (1989-12-14) * page 3, paragraph 3 * * page 5, paragraph 3 * * page 6, paragraph 1; claims 1, 3 *	1-16	TECHNICAL FIELDS SEARCHED (Int.Cl.7)
P, X	AIME S ET AL: "Non-covalent conjugates between cationic polyamino acids and GdIII chelates: a route for seeking accumulation of MRI-contrast agents at tumor targeting sites." CHEMISTRY (WEINHEIM AN DER BERGSTRASSE, GERMANY) GERMANY 14 JUL 2000, vol. 6, no. 14, 14 July 2000 (2000-07-14), pages 2609-2617, XP000113062 ISSN: 0947-6539 see conclusion * page 2613, column 2, paragraph 3 *	1-9, 13-16	
	-/--		

EPO FORM 1503 03/82 (P4/C10)



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Office

## PARTIAL EUROPEAN SEARCH REPORT

Application Number  
EP 00 31 0690

DOCUMENTS CONSIDERED TO BE RELEVANT			CLASSIFICATION OF THE APPLICATION (Int.Cl.7)
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	
T	<p>AIME S ET AL: "High-Relaxivity contrast agents for magnetic resonance imaging based on multisite interactions between a beta-cyclodextrin oligomer and suitably functionalized GdIII chelates."            CHEMISTRY (WEINHEIM AN DER BERGSTRASSE, GERMANY) GERMANY 17 DEC 2001, vol. 7, no. 24,            17 December 2001 (2001-12-17), pages 5261-5269, XP008009024            ISSN: 0947-6539            see conclusion            * abstract *</p>	1-16	
			TECHNICAL FIELDS SEARCHED (Int.Cl.7)

EPO FORM 1503 (03.02) (P4C10)



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### CLAIMS INCURRING FEES

The present European patent application comprised at the time of filing more than ten claims.

- ☐ Only part of the claims have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims and for those claims for which claims fees have been paid, namely claim(s):
- ☐ No claims fees have been paid within the prescribed time limit. The present European search report has been drawn up for the first ten claims.

### LACK OF UNITY OF INVENTION

The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

see sheet B

- ☒ All further search fees have been paid within the fixed time limit. The present European search report has been drawn up for all claims.
- ☐ As all searchable claims could be searched without effort justifying an additional fee, the Search Division did not invite payment of any additional fee.
- ☐ Only part of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the inventions in respect of which search fees have been paid, namely claims:
- ☐ None of the further search fees have been paid within the fixed time limit. The present European search report has been drawn up for those parts of the European patent application which relate to the invention first mentioned in the claims, namely claims:



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OfficeLACK OF UNITY OF INVENTION  
SHEET BApplication Number  
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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

1. Claims: 7,8,14 complete 1-6,9,13,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule consists on a paramagnetic metal complex and the carrier molecule is a cationic polymer as recited in claims 7,8. Use of the same in magnetic resonance diagnosis.

2. Claims: 10 complete 1-6,9,13,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule consists on a paramagnetic metal complex and the carrier molecule is a neutral polymer as recited in claim 10. Use of the same in magnetic resonance diagnosis.

3. Claims: 11,12 complete 1-6,9,13,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule consists on a paramagnetic metal complex and the carrier molecule is a neutral polymer as recited in claims 11,12. Use of the same in magnetic resonance diagnosis.

4. Claims: 1-6,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule consists on free radical with a carbon containing portion with 1 to 20 carbon atoms and the carrier molecule as recited in claim 5. Use of the same in magnetic resonance diagnosis.

5. Claims: 1-6,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule consists on perfluorocarbon with a carbon containing portion with 1 to 20 carbon atoms and the carrier molecule as recited in claim 5. Use of the same in magnetic resonance diagnosis.

6. Claims: 1-6,15,16 partially

Diagnostic composition comprising a non covalent carrier-hapten bioconjugate wherein the hapten molecule



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LACK OF UNITY OF INVENTION  
SHEET B

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The Search Division considers that the present European patent application does not comply with the requirements of unity of invention and relates to several inventions or groups of inventions, namely:

consists on free radical with a carbon containing portion with 1 to 20 carbon atoms and the carrier molecule as recited in claim 5. Use of the same in magnetic resonance diagnosis.

**ANNEX TO THE EUROPEAN SEARCH REPORT  
ON EUROPEAN PATENT APPLICATION NO.**

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This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on  
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

18-06-2003

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EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82

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